Title: Analysis of the SMAP Daily Soil Moisture Time Series through Power Spectrum-Adjustment Methods Utilizing Additional Datasets

Abstract:

Soil moisture (SM) analyses and assessments hold significance for numerous applications in the fields of hydrometeorology and agriculture. Throughout history, flux tower sites have been a primary source of data for observationally-based SM examinations and evaluations of land-atmosphere interaction. However, these monitoring stations are not evenly distributed worldwide. One of the ways in which the comprehensive understanding of how land and atmosphere interact can be improved is by incorporating remotely sensed SM observations.

The Soil Moisture Active Passive (SMAP) satellite is one of the satellite resources which closely aligns with in-site observations. However, the remote sensing nature of SMAP data means that it is prone to unpredictable random distortions. Since variations in SM tend to follow a fundamental Markov process, they typically display a specific “red noise” pattern of variability. On the other hand, satellite data that incorporates random fluctuations exhibits a more uniform “white noise” pattern at higher frequencies, which contrasts with the anticipated red noise pattern. Furthermore, gaps in SMAP data are not randomly distributed; due to its orbital characteristics, the satellite experiences regular instances of missing data during its 8-day orbital cycle, differing depending on the orbital pass. This introduces additional anomalies in the power spectrum, performed through examining correlations in the time series data, leading to recurring spikes at intervals of 8, 4 (half of 8), 2 and 2/3 (one-third of 8), and 2 days (one-fourth of 8). These spectral spikes become broader due to small variations in the satellite's orbit. To make the satellite data most effective for assessing land-atmosphere interactions, which tend to rely on estimates of covariability of SM with other environmental variables, it is crucial to minimize the impact of random distortions and systematic missing data.

A technique for adjusting the power spectrum, and thus the time series, of SM has been developed to minimize the influence of orbital harmonic spikes in the gridded Level 3 (L3) SMAP dataset. This is achieved by fitting a catenary function to the power spectrum between the harmonic spikes and then removing their influence. The adjusted spectrum is then aligned with soil moisture data from the surface layer, collected from sites within the AmeriFlux network (in-situ flux tower data). These sites demonstrate relatively minimal distortion and exhibit SM power spectra that closely resemble those generated by offline land surface models (LSMs), which are free of random noise by nature. Using validated spectral data from gridded LSM-based datasets, an improved global L3 SMAP dataset is being generated that accounts for noise and harmonic effects. This presentation will showcase the outcomes of this technique in enhancing SMAP data and its temporal correspondence with observational data.